RD Laboratories

Microelectronics Application

The RD Digital
TRACER

For use with the Sinclair ZX Spectrum

Contents

1. Introduction

1.1 THE RD DIGITAL TRACER

The RD Digital Tracer is manufactured by RD Laboratories, a division of Kane-May Measuring Instruments, for a range of popular personal microcomputers.

The use of high precision components and sophisticated calibration methods enable the use of the Tracer in quantitative measurement applications in addition to simple creation of complex graphics as described in this manual.

No software knowledge is required to operate the Tracer. Just following the instructions in this manual will soon allow the Tracer user to see the graphics potential of the ZX Spectrum. Previous knowledge of the computer, and access to the Spectrum manual, is of course an advantage, particularly in handling data files, and when graphics displays are to be transferred into the user's own program.

The copyright software provided is self-contained, but is accessible to Spectrum programmers who wish to modify it for specific app- lications. Understanding the BASIC software is facilitated by the inclusion of REM statements, and we have included software hints in Section 5.

1.2 THE MANUAL FOR THE ZX SPECTRUM TRACERS

This manual provides the full operating instructions for both the A3 and A4 tracing area versions of the RD Digital Tracer for the ZX Spectrum. These two variants are coded throughout the text as follows:-

A3 version   RD-ZX/A3
      (originally   RD-ZXP   or   ZX   Professional)

A4 version   RD-ZX/A4
   (originally   RD-ZXS   or   ZX   Standard)

Users are recommended to read the manual right through before setting up the Tracer for operation.

1.3 EQUIPMENT PREPARATION

(a) Mechanical Arrangement of the RD-ZX/A4

The RD Digital Tracer RD-ZX/A4 is supplied with a tracing sheet printed with a grid of approximately A4 paper size.

The Tracer arms are ready to fit to a drawing surface of your choice - a drawing board, light box, or direct to your desk or table top. A piece of white faced laminated chipboard 450 x 300mm forms an ideal board when laid out as in figure 1.(Although the tracing sheet defines a standard A4 tracing area of 256mm x 176mm, the Tracer will access most of this board area using the scaling facility described in section 4.3)
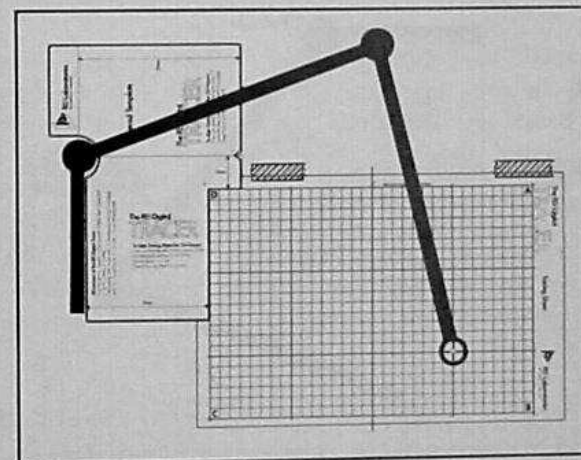
The short arm of the Tracer should be fixed parallel to the left- hand edge of the drawing surface, using the double sided adhesive strip supplied, or with a suitable clamp. Alternatively use screws for a more permanent installation.
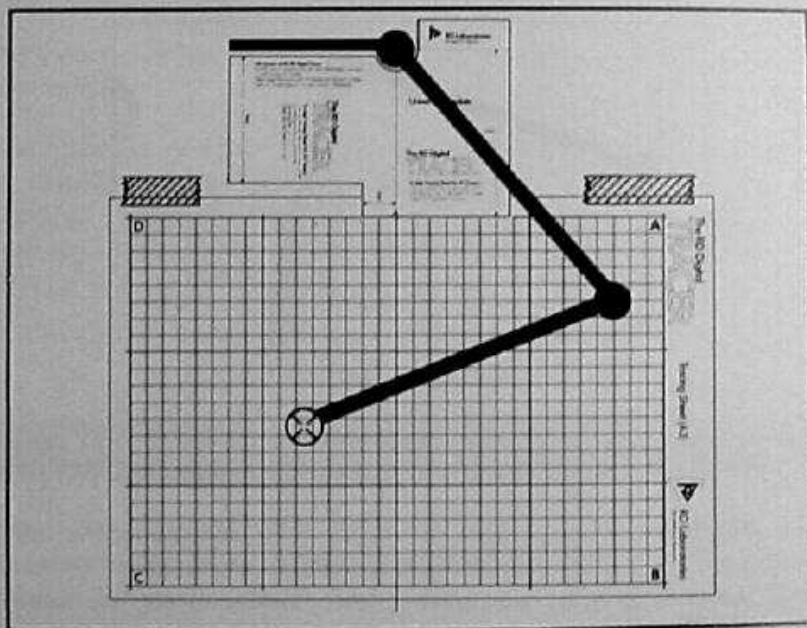
The left-hand edge of the grid on the tracing sheet must be parallel to the axis of the short arm at a distance of 100mm. A cardboard template is provided. This should be held or taped in position against the fixed Tracer arm while the tracing sheet is aligned with its corner cut-out "X". The tracing sheet may then be taped to the drawing surface and the template may be removed.

The tracing sheet grid now defines the area which will be transferred to the full graphics screen when the Tracer is operated with standard scaling. Drawings to be copied should be secured within the grid outline, ideally with horizontal and vertical lines aligned with the grid.

(b) Mechanical Arrangements of the RD-ZX/A3

The RD Digital Tracer type RD-ZX/A3 is supplied with a clear tracing sheet overprinted with a grid of approximately A3 paper size.

The Tracer arms are ready to fit to a drawing surface of your choice - a drawing board, light box, or direct to your desk or table top. A piece of white faced laminated chipboard 450 x 600mm forms an ideal board when laid out as in figure 2. (Although the tracing sheet defines a standard A3 tracing area of 400mm

x 275mm, the Tracer will access most of this board area using the scaling facility described in section 4.3)

The short arm of the Tracer should first be fixed parallel to the top edge of the drawing surface, using the double sided adhesive strip supplied, or with a suitable clamp. Alternatively use screws for a more permanent installation.

The top edge of the grid on the tracing sheet must be parallel to the axis of the short arm at a distance of 125mm. A cardboard template is provided. This should be held or taped in position against the fixed Tracer arm while the tracing sheet is aligned with its bottom edge "Y". The tracing sheet may then be taped to the drawing surface and the template may be removed.

The tracing sheet grid now defines the area which will be transferred to the full graphics screen when the Tracer is operated with standard scaling. Drawings to be copied should be secured within the grid outline, ideally with horizontal and vertical lines aligned with the grid.

(c) Electrical Connection

The RD Digital Tracer and any other accessories must be connected to the Spectrum computer before power is applied.

The 23-way edge connector of the plastic-cased Tracer interface will connect directly with the 28-way edge plug at the rear of the Spectrum. If a printer is also connected, this should be plugged into the Spectrum, with the Tracer connected behind the printer connector.

A cassette recorder and television should be connected in the normal manner as described in the Spectrum manual. Finally, connect the Sinclair Power Supply to the Spectrum, and switch on.

WARNING
On no account should the Tracer be disconnected or connected while the computer is switched on. This applies to any accessory connected via the 28-way plug.

The computer and other equipment could be damaged by failure to observe this warning.

Insert the cassette provided in the cassette player, ensuring that the tape is rewound to the start.

Type LOAD""[ENTER]

Start the cassette player with the PLAY switch.

After a few seconds the television will display a catalog of the tape contents, with instructions for users of 16K and 48K Spectrum computers. The program will then automatically detect which machine is in use and load the program "Tracer48" or "Tracer16" as appropriate. The program will load in approximately 2 minutes.

If the program fails to load, switch off the computer and check all the connections. Referring to the Spectrum manual repeat the LOAD routine with a different VOLUME setting on the cassette player. With most cassette machines a setting of 75% of full volume should be satisfactory.

When the program has loaded the television screen will confirm this fact and flash the instructions

SWITCH OFF CASSETTE RECORDER
PRESS ANY KEY TO CONTINUE

(N.B. Users of the RD-ZX/A3 should refer to section 1.5)

When a key is pressed the screen is cleared, setting up a black background (PAPER) colour surrounded by a blue BORDER. Provided the Tracer head is within the grid outline of the tracing sheet a white flashing cross, the CURSOR, will be seen. The cursor on the screen indicates the Tracer position on the paper, following every movement of the Tracer arm.

1.5. AUTOMATIC ARM CALIBRATION

The A3 version of the Digital Tracer (RD-ZX/A3) is capable of highly accurate mapping from paper - with an error of less then 1% of full scale. Consequently its software includes an automatic routine providing a fine calibration.

When the program has loaded the screen displays the instructions

SWITCH OFF CASSETTE RECORDER
ARM CALIBRATION? PRESS Y or N

Initially the program prepares to execute an automatic calibration routine. This compensates small aligment errors in the position of the tracing sheet and calibration discrepancies between computer on a "best-fit" basis, i.e. taking samples at four calibration points on the tracing sheet grid. Type Y (for yes) in response to the invitation ARM CALIBRATION?

ARM CALIBRATION?

| Y | YES |
| N | NO |
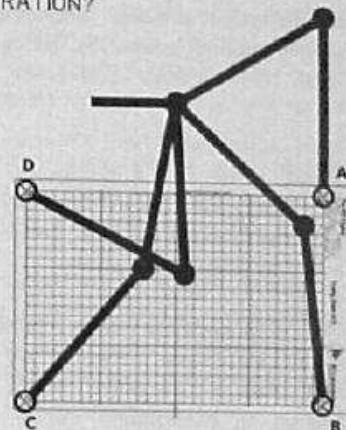
As prompted by the screen display, place the Tracer head at each corner in turn, and press the [ENTER] key. These points must be sampled in the prescribed order A to D, and placed with precision, as the final drawing accuracy is determined by this operation.

If an error is made at this stage, press the [BREAK] key and restart the program by typing RUN [ENTER]

Normally it is neccessary to execute this operation only once, each time the machine is switched on. If the program is restarted, typing 'N' in response to the invitation ARM CALIBRATION? will skip this routine.

(A restart should be executed by the instruction GOTO 8100. This will restart the program without affecting any variables previously defined.)

2. Creating Computer Graphics

2.1 SIMPLY CREATIVE

The ZX Spectrum computer provides excellent graphics facilities, offering 8 colours with medium resolution, but with only a moderate proportion (less than 7K) of RAM committed to display memory.

The graphics screen area comprises 22 rows of 32 characters. Each character square is an 8 x 8 matrix of 64 pixels - a pixel being the smallest "dot" which can be resolved (i.e. controlled by the computer to be present or not present). The resolution is therefore expressed as 256 x 176 pixels.

The colour control is applied to each character square, which can have two colour attributes. INK is the colour assigned to foreground colour - that is the pixels which are "ON". PAPER is the colour assigned to background colour - the pixels which are "OFF". This system, leading to conservation of memory, is less flexible than full resolution colour systems, which enable the colour of every pixel to be defined independently. In practice this causes a problem only when more than 2 colours are required within a given character square.

It is recommended that Tracer users who are unfamiliar should study chapter 16 of the Spectrum manual in order to obtain best results.

However, it should be possible with little or no knowledge of BASIC to start producing screen graphics immediately, simply with reference to the comprehensive instructions in this manual.

3. The Drawing Commands

3.1 INTRODUCTION

As has been demonstrated already, the flashing cursor (which cannot corrupt the image set up on the display screen) follows every movement of the tracing head. This indicates where the drawing functions assigned to certain keys will be executed.

The Tracer is principally designed to copy graphical details from an original drawing or diagram, but may be used also for freehand drawing - viewing the movements of the cursor on the screen.

Most of these commands are executed immediately, or continue to operate while the key is pressed. The computer will "beep" to acknowledge each key press. Some are "Input" commands requiring an entry from the keyboard followed by [ENTER].

The use of a MENU for selection of drawing commands has been avoided so as not to interupt the creative drawing process. The key commands are summarised on a chart at the end of section 4, and where appropriate the Tracer commands are executed using the same keys as the equivalent commands in Spectrum BASIC.

The bottom two lines of the screen consist of a control panel, displaying current colour and mode selections. These will be explained as the respective drawing commands are described.
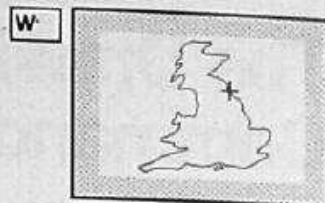
3.2 POINTS, LINES AND RUBBING OUT

Plot

Plots a single point (pixel) at the cursor position.
First position the cursor by moving the tracing head. The point is plotted immediately key [Q] is pressed.
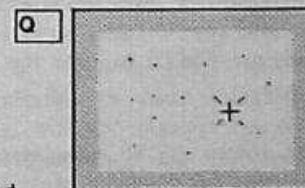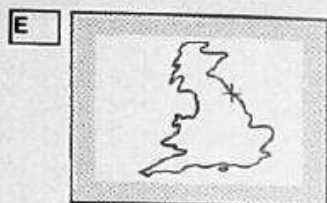
Draw

draws a continuous outline following
the Tracer movement while Key [W]
is kept depressed.

On depressing [W] the cursor disappears and reappears when [W]
is released. Thereafter the Tracer may be moved without a
line being drawn on the screen.

Emphasised Drawing

draws a continuous line as command
[W] but of double thickness.

Pressing [E] while the Tracer is stationary will produce a double
size dot, consisting of a square block of four pixels.

Connect

draws a sequence of straight line
segments joining or connecting
Tracer points.
Place the Tracer at the first point and press [I] to fix the "Initial
point". (This point is not plotted yet.) Now move the Tracer
to the second point and press [C]. A straight line will be drawn
to connect with the invisible first point. Move the Tracer to
the third point and press [C] again. A straight line will be drawn
to connect with the previous (second) point. This process may
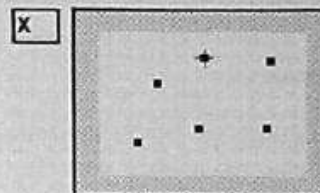be repeated indefinitely.

Clear Graphics Screen

Simultaneously press the [CAPS SHIFT]
key and key 'V' (used for CLS in
Spectrum BASIC) to clear the entire
Screen.
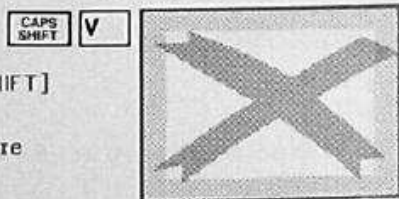
The screen will be replaced by a uniform background of the colour
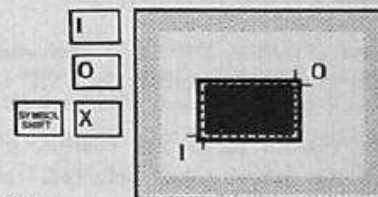specified for PAPER in the control panel.

Delete Character Square

Press key [X]

The block of 8 x 8 pixels comprising the character square at
the current Tracer position will be deleted. Also the PAPER
colour of this square will be changed to that specified in the
control panel.

Delete Rectangle Block

Define the rectangle using keys
[I] and [O] as described for
Automatic Constructions in
section 3.5.
Then press [S/S] and [X] simultaneously.

Note that the rectangle thus defined is comprised of complete
character squares. In general therefore the erased rectangle
area will be larger than the rectangle outline drawn using [I]
and [O].

The background of this rectangle area will be set to the current
PAPER colour. If this is not to be changed, first select PAPER
colour 8 by pressing [S/S][8].

3.3 COLOUR CONTROL

The RD Digital Tracer uses the standard ZX Spectrum BASIC
commands as described in chapter 16 of the Sinclair manual.
Tracer users who are not already familiar with these Spectrum
BASIC commands will find it useful to refer to the Sinclair manual
while experimenting with the colour control commands described
on this section.

In Sinclair BASIC the codes 0 to 7 are used to specify the
eight posible colours (assigned as attributes to each character
position) which define INK, PAPER and BORDER colours. Codes
8 to 9 may also be used to specify "transparent" and "contrast"
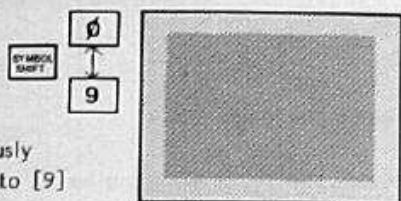as explained in the Sinclair manual.

Border

Press [CAPS SHIFT] simultaneously with one of the number keys [0] to [7].
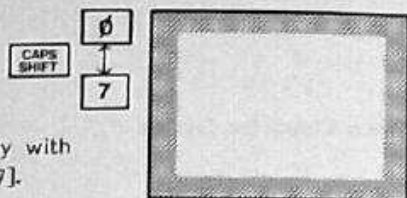
Without changing the contents of the graphics screen, the surrounding border colour will change immediately to that printed by the appropriate number key.

Paper

Press [SYMBOL SHIFT] simultaneously with one of the number keys [0] to [9]

The control panel will change, including the colour code number and the actual colour selected. Initially, however, nothing changes on the graphics screen.

If the screen is to be cleared with this new background colour, press [C/S][V].

Alternatively, this paper colour definition is used to PRINT TEXT, and to effect local background colour in a rectangular PAPER BLOCK, as described on page 13.

Ink

Simply press one of the number keys.

The control panel will change immediately, indicating the colour and code selected.

All subsequent drawing commands will then be executed in the selected colour. These include line drawing, constructions, colour filling and text.

Note, however, that the cursor and sample constructions will always appear in a "transparent" colour to avoid permanent corruption of the display.

Grid Overlay

Press [CAPS SHIFT] simultaneously with key [G]
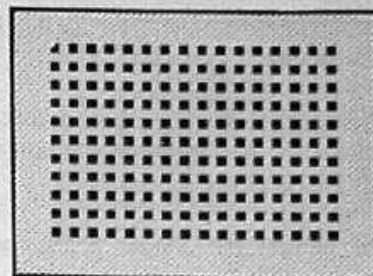
The screen is painted with an overlay consisting of alternate darkened squares in alternate rows. This is removed without corrupting the screen design by pressing [C/S] [G] a second time.

This function clearly defines the position of each character square, positioned in a 32 (horizontal) by 22 (vertical) matrix. This facilitates complex designs involving several colours, with the Spectrum limitation that colour attributes are assigned by characters.

N.B. Due to loss of screen contrast on black and blue backgrounds this function is best used on PAPER colours 2 to 7.

Paper Block

First define rectangle to be coloured using [I] and [O] Then press [SYMBOL SHIFT] simultaneously with key [C] to paint background rectangle.
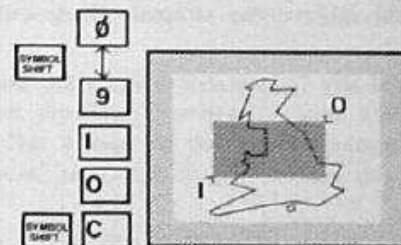
This command permits a local background (i.e. PAPER) colour to be applied to any rectangle area **consisting of complete character squares.** This may be executed before or after foreground detail has been drawn - it will not delete foreground (i.e. INK) pixels, as does the DELETE RECTANGLE command [S/S] [X].

The command is executed in three stages. First select the required PAPER colour, as above, using [S/S] [0] to [9]. Next, define the rectangle to be coloured using keys [I] and [O] to set opposite corners as in the automatic construction of a rectangle (Section 3.5). The grid overlay is useful here to display the related character squares. Finally press [S/S][C] to paint the rectangle.

Fill Outline

[F]

fills with current foreground (INK) colour an enclosed outline already present on the graphics screen.
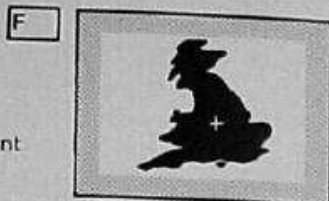
By moving the Tracer place the cursor within the **closed** outline to be fillied. Press key [F]. Shading will commence from a point on the outline vertically below the cursor position. It continues as a series of ascending horizontal lines, and stops when the centre of such a line coincides with the upper part of the outline.

On complicated outlines "pockets" may be left unfilled. Move the cursor into an unpainted area, and press [F] again.
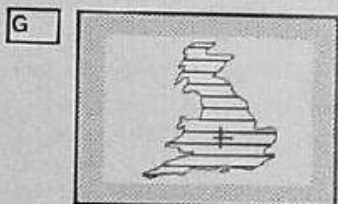
Hatch Outline

[D]

This command is identical to Fill [F] but with a different shading characteristic.

Key [D] hatches alternate lines

[G]
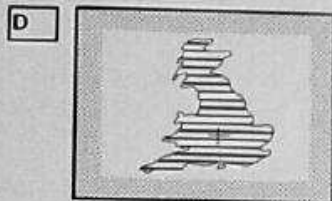
and key [G] hatches every third line.

FURTHER COLOUR VARIATIONS BY CONTROL OF MODE

The bottom line of the control panel displays the current setting of four mode selections as follows. Pressing the appropriate key once will change the mode. Pressing it a second time will change it back again.


Fill mode

[SYMBOL SHIFT] [M]

Press key [M] simultaneously with [SYMBOL SHIFT] to change the Fill Mode.
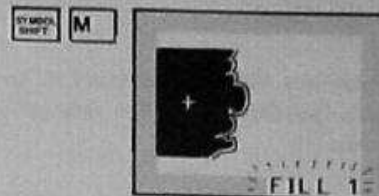
Fill mode 0, the initial (or default) setting requires that an outline is closed – a left and right boundary, in order that the colour fill routine [F] will operate. Selecting fill mode 1 enables shading between the **border** and a **single** drawn line as shown.

Over Mode

[SYMBOL SHIFT] [N]

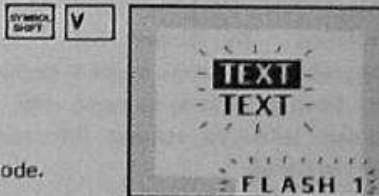Press key [N] simultaneously with [SYMBOL SHIFT] to change the OVER mode.
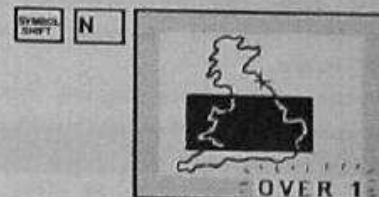
The characteristic is appplied exactly as for the Sinclair BASIC command. The default mode OVER 0 is for normal drawing where foreground colour is added progressively to the screen. When a pixel or line is drawn over existing foreground colour in the OVER 1 Mode, the coincident pixels are deleted, leaving the PAPER colour showing through. This is often referred to as "Exclusive – OR" printing.

The OVER mode is applied to all drawing commands – lines and points, constructions and text. **The prompt in the control panels flashes as it is essentiial to reset to OVER 0 for normal use.**

Try using the command **Delete Character Square [X]** while in OVER 1 mode. The paper colour of that square will be changed, but the foreground detail and INK colour is not altered.
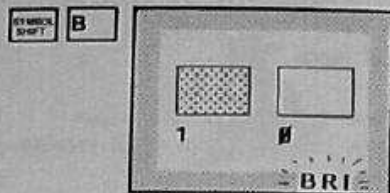
Flash Mode

[SYMBOL SHIFT] [V]

Press key [V] simultaneously with [SYMBOL SHIFT] to change mode.

This operates only with text printed on the graphics screen, as with the standard Spectrum BASIC command. Characters appear alternately in normal and colour inverted form.

Bright Mode

[SYMBOL SHIFT] [B]

Press key [B] simultaneously
with [SYMBOL SHIFT] to change
mode.

As in Spectrum BASIC, the BRIGHT command provides additional
contrast ("grey-tone") control. The default setting of 1 gives
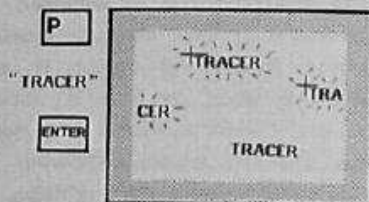the brighter version of the selected colour.

This mode control is effective on PAPER colours selected and
on text, but not on other drawing commands using foreground
INK colour.

3.4 PRINTING TEXT

Print

[P]

[ENTER]

prints alphanumeric characters
anywhere on the graphics screen.

Press key [P] and the prompt

ENTER TEXT: "L"

is displayed. Enter the text you wish to print onto the display
and press [ENTER]. You will now see the text flashing at the
cursor position, and the prompt

MOVE TEXT
[P] TO PRINT, [SPACE] TO DELETE

displayed. By moving the Tracer you can move the text on
the screen to any desired position. When the correct position
has been obtained, pressing [P] will print it. The text will be
printed with the current INK and PAPER colours being displayed
on the panel.

Alternatively, if a satisfactory position cannot be achieved, press
[SPACE] to erase the text completely. e.g. if text is too long
-overflowing the right-hand edge of the screen.

Repeat Text [S/S][P]

If the same text is to be printed at several different positions
then pressing [S/S] [P] will display the last text entered, and
the prompt

MOVE TEXT
[P] TO PRINT, [SPACE] TO DELETE

will again be displayed. Proceed as above.

Colour Control Text

It will be apparent that the text printed as described above
appears with the character of the current INK colour and a
local background of the current PAPER colour. This applies
equally for REPEAT TEXT. It may be useful to change INK
and PAPER colours before repeating the text at a new position.

Spectrum users who are familiar with the use of extended mode
to insert colour codes in text strings (chapter 16 of Spectrum
manual) may use this technique while entering text. This will
however paint the screen with INK and PAPER attributes when
the sample text is moved.

Inverse Text

Although INK and PAPER selection provides any colour combi-
nation, it is also possible to use INVERSE text mode by typing
[C/S] [4] when entering text in response to the prompt

Enter text:"L"

User Graphics

User graphics characters can be entered, even mixed with standard
characters, in the normal way. When entering text type [C/S]
[9] for the graphics mode. Repeat this code to return to normal
character mode.

N.B. Do not enter strings of more than 17 characters.
This would corrupt the screen in scrolling the display by one
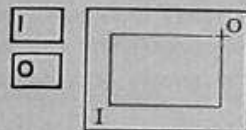**line.**

3.5 AUTOMATIC CONSTRUCTION

Fundamental shapes incorporating straight lines, arcs and circles may be drawn automatically by the computer, using the Tracer to specify just two points. Using the techniques of computer aided design these shapes can be extended, moved and repeated instantly.

"Elastic" Drawing

For all of these constructions the INITIAL POINT is fixed by positioning the Tracer and then pressing key [I]. The standard shapes are then drawn from the fixed initial point to the current Tracer position in a sample mode – the selected shape is drawn and erased, without corrupting the existing screen display.

Having fixed the INITIAL POINT, move the Tracer to the second point and press the key appropriate to the shape required. The Tracer may be moved with this key held down, to stretch the selected shape.
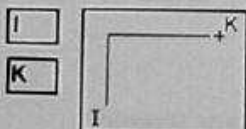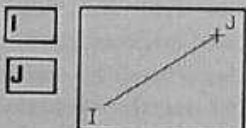
Rectangle, specified by opposite corners
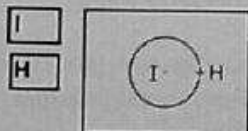
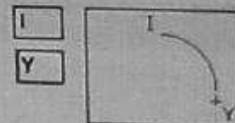Right angle pair, horizontal first
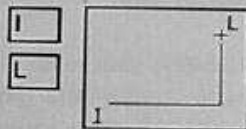
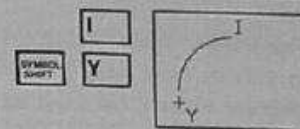Right angle pair, vertical first

Straight line

Circle with centre at initial point. Second Tracer position fixes the radius.
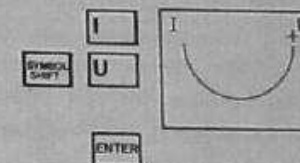
Clockwise 90° arc

Anticlockwise 90° arc

Clockwise 180° arc

Anticlockwise 180° arc

N.B. If the radius specified for the circle would require drawing off the screen, then the command will be ignored. If the arc dimensions take the drawing off screen the program will stop with an error message. To return to the program press [RETURN] [ENTER][RETURN][ENTER].

Print, Move and Repeat

To permanently print the sampled construction, in the INK colour specified in the control panel, press [ENTER].

Alternatively, to move the construction, press and hold [M], and move Tracer to the new position. Press [ENTER] again to print permanently in the new position.

This MOVE command can also be used to REPEAT the construction, even after other commands, such as INK colour change, have been executed.

This will repeat only the last construction defined.
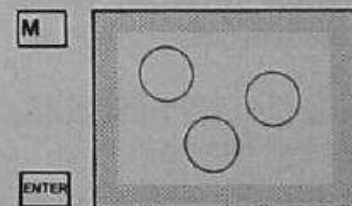
Copy

The printer starts and stops automatically
to provide hard copy of the complete
graphics screen, by pressing [Z].

The printer paper is automatically
advanced to provide separation
between subsequent copies. Alternatively, use [S/S][Z] to provide
continuous copies without separating line spaces.

N.B. This command will operate with any printer which provides
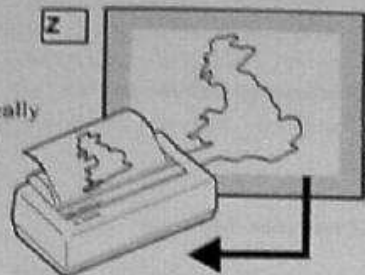a screen dump using the Spectrum BASIC command COPY.
This includes the ZX Printer, Alphacom 32, and standard dot-
matrix printers when using an appropriate Centronics Interface.

Save SCREEN$

At any stage in the creation of a screen
design it may be saved on cassette.

Press [S/S] and [K]
simultaneously.
The computer prompts

Enter file name "L"

Type in a name for identification, not exceeding 11 characters,
and then press [ENTER]. Ensure that the cassette recorder is
properly connected for saving, and recording. Then press [ENTER] again.

This screen display may be loaded back into your own programs,
which do not use the Tracer program. Use the Spectrum BASIC
command LOAD "file name" SCREEN$. This can be set up to
load from within your program. Chapter 20 of the Spectrum
manual describes these commands in detail.
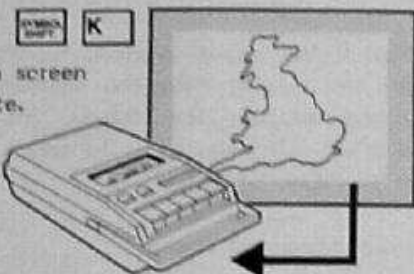
Load SCREEN$

Press [S/S] and [J] simultaneously
and play cassette.

The computer will load the next screen dump which it finds
on the cassette. This will completely replace the current screen
display and the Tracer can then be used to modify the newly
loaded display.

By this means displays created from other sources can be loaded
into the Tracer software for further modification.

Store Display (48K only)

The 48K software supplied
reserves two blocks of
memory as temporary
screen stores
identified as J and K
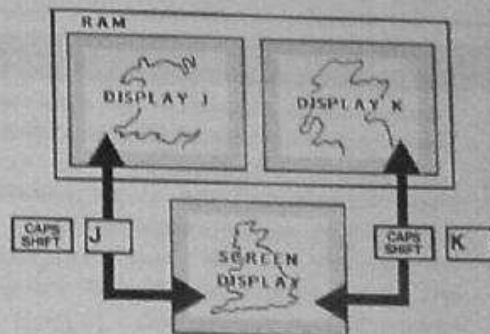
Press [C/S][J] and the current (viewed) screen is exchanged
with store J. Similarly, [C/S][K] will exchange the current
display with store K.

This is particulary useful if the screen is to be used for listing
the program, or setting up user graphics.

Current screen copy
– to J.
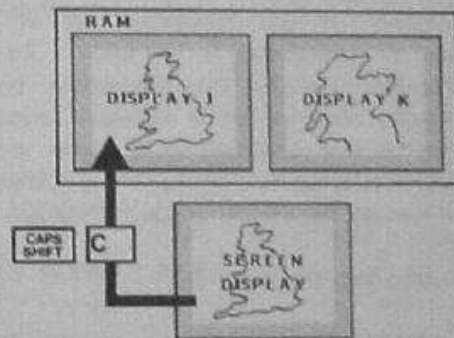
This function gives you the facility to copy the current screen
to the RAM store J, rather than just interchanging between
current screen and RAM stores J and K.

Therefore, you can always work from an original which is copied
into J after every interchange.

Warning. This will destroy the former display in Store J.

4. Advanced Graphics Manipulation (48K only)

4.1 INTRODUCTION

These facilities are available only on the 48K program supplied.

The commands described so far provide comprehensive facilities for emulating on the computer display, the conventional drawing methods used for INK on PAPER. (We recommend that the user should become familiar with the previous commands before working through this section.)

4.2 DYNAMIC RETRACE ACTION

The drawing commands presented so far all operate in "real time". The current Tracer position is sampled, and determines the screen position for a drawing command to be effected. The retrace action utilises the computer memory to store a sequence of key commands together with the appropriate X and Y co-ordinates in an array. Each element of the array therefore contains the information needed to reproduce the drawing sequence as it appeared originally on the screen. It may be that only part of a screen display is to be stored for later retracing. The user must therefore consciously decide to turn on the TRACE action, as follows.

Tracing into the Array [T]

To turn trace on, simply press the key [T]. The prompt

TRACE STARTING AT # " "

will be displayed. Enter start value, which will initially be 1. The program is now storing consecutive points from the Tracer, the X and Y co-ordinates, and the key pressed. These will be stored in three arrays. The sample number # (at the bottom of display) is the array variable or index. It is therefore possible to trace many outlines, stored at different points in the array, and to recall any one by commencing the retrace at the appropriate sample number. This way several independent displays may be created and held in the array. Any one of these can be displayed by starting at the appropriate array index. This is a very powerful feature for making presentations and demonstrations, especially as the display is recreated in the order it was traced in, i.e., dynamic reconstruction of display.

A feature which is of great value when retracing is the ability to stop the retrace until one wishes to restart it. One may wish to elaborate on a part of a display before constructing the rest of it. To obtain this STOP in retrace, press key [A] (Stop key) while tracing. This does nothing while tracing but the effect will be seen in Retrace.

Stop Tracing into the Array [S/S][T]

When tracing is complete stop the Trace action. This is done by pressing [S/S][T]. To confirm that Trace has been turned off, a prompt will be displayed

Trace stopped at #?

Note:- When the computer asks for the start value of a trace, pressing [ENTER] will start tracing from where trace was previously stopped.

Retrace [R]

To retrace the displays created, simply supply the start index value. On pressing key [R] the prompt

COMMENCE RETRACE AT #?

is displayed. Enter the appropriate start value. The display will now be reconstructed in "real time".

Start Selective Retrace [S]

The [S] key is used to retrace a particular part of the array. Start and stop array values can be specified.
See the example which follows for a detailed description.

If an error is made in tracing, it can be edited by going back to the value where the error ocurred. Make sure that you stop Trace, and then restart tracing at the value at which you went wrong. It is good practice to keep a note of the index value at the bottom of the screen.

If you -trace a display at 0-100 and another at 500-800 then you can trace another display between 101-499, provided no text is used. Generally try to Trace displays continuously, because you can access any part of the array using the [S] function.

If the program breaks while Trace or Retrace are operating do not type RUN, but GOTO 8100. Typing RUN will delete the arrays.

You can input a maximum of 150 separate 16-character words using Trace.

USER PROGRAM EXAMPLE

- incorporating Trace/Retrace and stores J and K.

For this example we will use a simplified network of the main ports, Inter - City services between these ports, Airport network and the Television network. The user program will select one of the networks from the menu and **superimpose** it on the map of the British Isles.

This example is on the software cassette supplied, and the user program is at lines 1000 -2000.

We shall now describe how the displays were created and put together.

1. Trace out the British Isles and store into store J. [C/S][J].

CAPS SHIFT

J
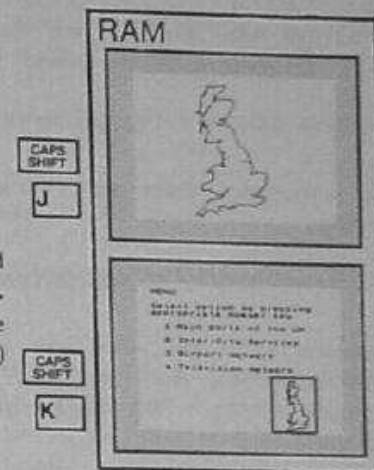
2. Create the menu page and store in store K. [C/S][K]. (This can be also done in the user program by print statements)

CAPS SHIFT

K

3. Bring back the map of the British Isles from store J [C/S][J] and **copy** it back to store J [C/S][C]. So as to keep a copy of the original.

CAPS SHIFT
J
CAPS SHIFT
C
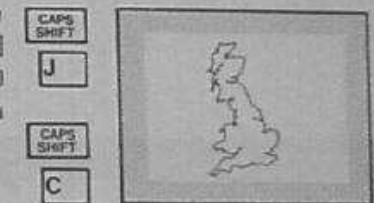
4. Set trace on and trace outthe main ports. Turn trace off. **Note start and stop trace values.**

T
SYMBOL SHIFT
T
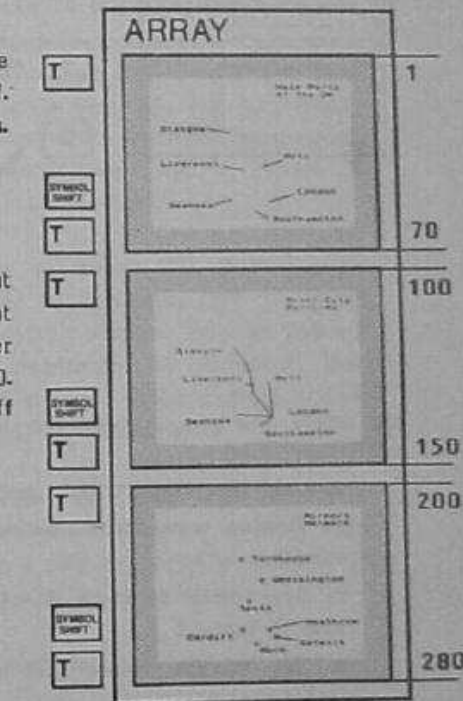
5. Repeat steps 3 and 4, but commence trace at a convenient point for each of the other displays e.g. 100, 200 and 300. Make sure you turn trace off after each display and note start and stop values.

T
SYMBOL SHIFT
T
T
SYMBOL SHIFT
T

RAM

ARRAY

1

70

100

150

200

280

You can view any of these displays using the set trace function [S]. On pressing [S] the prompt

START RETRACE AT # ?

is presented. Enter start value and press [ENTER]. Now the prompt

AND RETRACE TO # ?

appears. Enter the value you noted at the stop of Trace, **OR** any value less than the start value of next traced segment. Press [ENTER]. The display/design previously constructed will be recreated.
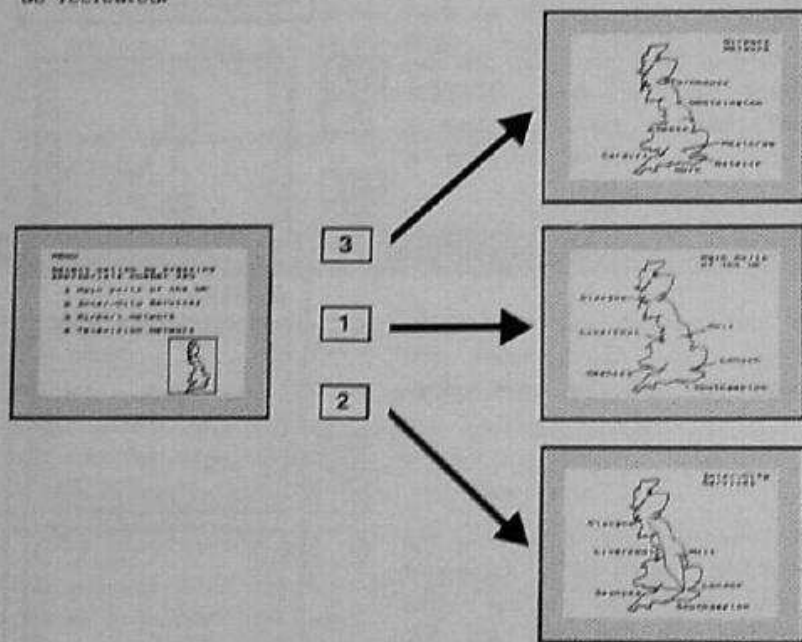
The simple user program does the following steps:-

 a. Load the program, data and displays.
 b. Display menu from store K and wait for option to be selected.
 c. Save menu to store K. Display map from store J. Copy map to store J.
 d. Set retrace values and retrace. Wait for key press. GOTO step b.

The save routines at the end of the user program are required to save the user program, data and display.

Remember to execute the command CLEAR 50943 BEFORE loading the program i.e.

CLEAR 50943: LOAD""

This will be different if you change RAMTOP. The more adventurous can set this up as a loader page.

The simplified example shows four displays, which are basically labels for the map. More complex displays can be held in the array e.g. kitchen designs, circuit diagrams, human organs/limbs, complex irregular shapes etc. Any of these can be simply retraced or superimposed.

4.3 AUTOMATIC SCALING

All the drawing commands introduced to this point involve transferring or mapping shapes from paper to screen in a fixed scale. The full grid area 256mm x 176mm maps on to a screen area of 256 pixels x 176 pixels. The scale vertically and horizontally is 1 pixel to 1mm. This is referred to as the normal scale, for the A4 Tracer. (The A3 Tracer maps 400 x 275mm to 256 x 176 pixels, a scale of 0.64 pixels to 1mm.)

A routine is provided to increase or reduce the relative scale. Vertical and horizontal scales may be different, and the image may be reversed (left to right) and/or inverted (top to bottom) If the scale is changed before commencing a RETRACE, then the resulting image is scaled and shifted. Thus multiple images can be produced from one tracing of an outline.

The scaling is carried out by specifying only two points on the screen, and the two related points on the paper. The two points may conveniently be a pair of opposite corners of a rectangle which "frames" the drawing to be transferred.

Scaling can be set up by two methods, and can be reset to normal by a single key command.

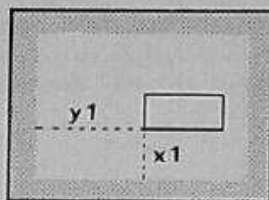|	
[SYMBOL SHIFT] [R]	**Resets** to normal scale
[SYMBOL SHIFT] [E]	To **Enter** a numerical scale factor.
[SYMBOL SHIFT] [D]	To **Draw** on the screen a reference rectangle into which drawing is scaled.
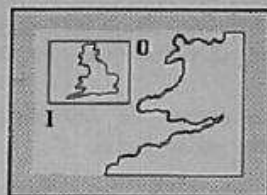
Setting Scale and Entering Scale Factor

Press [S/S] and [E] simultaneously.

The computer prompts

> **Scale Factor =**

Type in the numerical scale factor, followed by [ENTER]. This will be less than one for a reduced scale. The computer will then prompt

> **Screen Coordinate x 1 =**

Type in the horizontal reference position (on screen) on a scale Ø to 255, followed by [ENTER]. The computer will then prompt

> **Screen Coordinate y 1 =**

Type in the vertical reference position (on screen) on a scale Ø to 175, followed by [ENTER]. The computer now prompts

TRACER AT REF. POINT. ENTER

Place the Tracer on the paper at the point which should map to the screen coordinates previously specified, and press [ENTER].

The cursor will now return on the display, moving according to the new scaling characteristics.

Setting Scale by Drawing Scaled Area

It may be useful first to return to normal scaling by pressing [SYMBOL SHIFT] and [R] simultaneously.

Press [SYMBOL SHIFT] and [D] simultaneously.

Follow the further instructions given on the screen to draw a rectangle on the screen, into which the scaled drawing is to be filled. As with the rectangle construction described in

section 3.5, [I] and [O] are used to define opposite corners. The bottom left corner should be fixed with key [I] and the top right corner with key [O].

Then press [SYMBOL SHIFT] and [G] simultaneously.

It is now necessary to specify the physical rectangular area on paper **from which** the drawing is made, again using opposite corners. In response to the two prompts place the Tracer in turn at the bottom left corner, and top right corner, pressing [ENTER] each time.

This second scaling procedure allows drawings to be mirror-imaged (left to right) or inverted (top to bottom) by suitably reassigning the bottom left and top right corners. Indeed, the vertical and horizontal scale factors can be different.(Note in this case that automatically constructed circles and arcs will not become elliptical!)
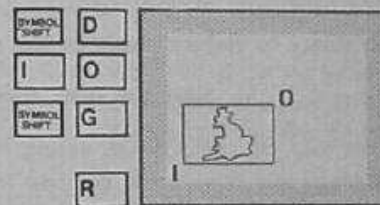
Step and repeat action

The scaling feature may be combined with RETRACE described in the previous section to repeat a drawing feature at several positions, and at different sizes, as required.
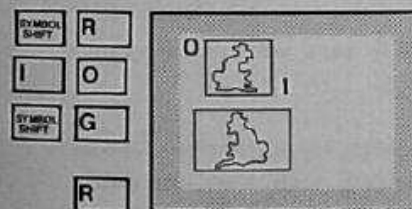
Trace design into array
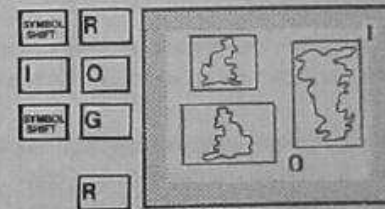

Set new scale with [I] and [O]
Commence retrace [R]

Reset scale to normal
Set new scale with [I] and [O]
Commence retrace [R]

Reset scale to normal
Set new scale with [I] and [O]
Commence retrace [R]

The following points should be remembered

1. If a reduction scale is applied *before* the drawing is traced, it is the screen coordinates which will be stored in the array.

2. Subsequent magnification scales will exaggerate the digital "pixel" nature of the drawing. It is best therefore to trace at maximum scale.

3. New scaling factors can be applied indefinitely before retracing.

4.4 USING DISPLAYS IN USER PROGRAMS

Read x,y [C/S][Z]

Press [CAPS SHIFT] and [Z] simultaneously, or hold these keys down together to display the Tracer coordinates in the panel. This may be useful when using the Tracer to measure features on a drawing, or returning to a specified position.

Save program (with variables) [S/S] [S]

Press [SYMBOL SHIFT] and [S] simultaneously.
Start the cassette machine in record mode, and press any key to commence saving. Remember that the program is saved in two segments (BASIC followed by machine code) so it will be necessary to respond again to the prompt

Start the tape, then press any key

This may be useful when saving modified versions of the program, although less tape would be used by breaking out from the program and typing

CLEAR [ENTER]
GOTO 9920 [ENTER]

This avoids unneccesarily saving the variable and arrays.

The prime importance of this command is to save with the program the retrace arrays which have been created.

The program, with arrays, can be loaded back for further amendment on a future occasion, or may be merged with user software which calls the retrace subroutine. (See next section for suggestions.)

Creating User-defined Graphics [C/S][U]

In section 3.4 it was explained that user-defined characters may be entered and printed in the same way as standard characters. Pressing [CAPS SHIFT] and [U] simultaneously enters a routine which sets up any character one pixel at a time.

Note that this routine will clear the screen. If it is called after beginning to design a display screen, the latter should be preserved by storing in RAM or saving on cassette — unless of course it is already resident in the trace array from which it can be retraced.
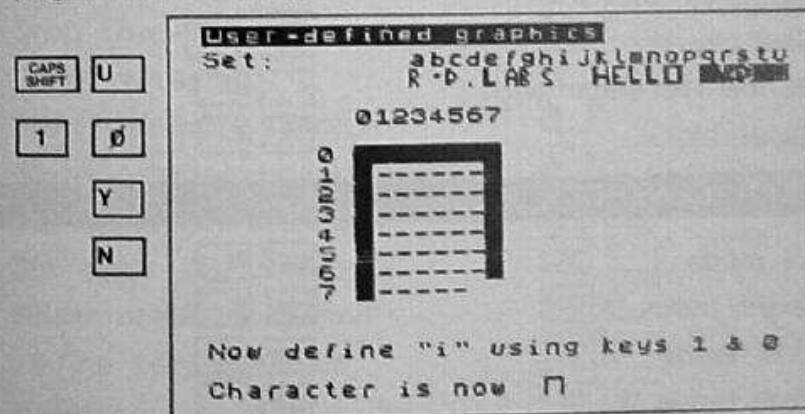
The top of the screen displays the current character set. The centre of the screen will be used to build up a large 8x8 matrix representing the character.

In response to the prompt, input character (a to u) which is to be defined, followed by [ENTER].

Next construct the character line by line, pressing [1] to deposit a pixel and [Ø] to insert a space. If an error is made while composing a line press [Y] to return to the beginning of the line.
To quit a line press [Q].

After completion of the bottom line you are invited to continue with a new character [Y] or return to the main program [N]. Characters thus created will be saved automatically by the save program command [S/S][S].

Summary Chart of Key Commands

POINTS, LINES AND RUBBING OUT

Code	Command	Keys
Ø3/3	Plot a point	[Q]
#2gg	Connect points	[C]
Ø3/g	Draw line	[W]
Ø3ør	Emphasised line	[S]
Ø28b	Clear screen	[CAPS SHIFT] [V]
Ø82-	Delete character square	[X]
Ø2gb	Delete rectangle	[CAPS] [X]

COLOUR CONTROL

Code	Command	Keys
Ø2Ø8/96	Ink colour	[Ø] to [9]
Ø29Ø/93	Paper colour	[CAPS] [Ø] to [9]
Ø2Ø4	Border colour	[CAPS] [Ø] to [7]
Ø3Ø2	Colour fill	[F]
Ø2øø	Hatch (2)	[D]
Ø3Ø3	Hatch (3)	[G]
Ø29/	Grid overlay	[CAPS] [G]
Ø3Ø9/3//	Define rectangle with	[I] [O]
Ø263	Paper block	[CAPS] [C]

MODE CONTROLS

Code	Command	Keys
Ø2Ø6	Fill mode	[CAPS] [M]
Ø242	Bright mode	[CAPS] [B]
Ø244	Over mode	[CAPS] [N]
Ø247	Flash mode	[CAPS] [V]

TEXT AND CONSTRUCTION

Code	Command	Keys	Command	Keys
Ø3/2	Print text	[P]	Repeat text	[CAPS] [P]
Ø3ør	Initial point	[I]	Straight line	[J]
Ø3Ø4	Circle	[H]	Rectangle	[O]
	Right angle		Right angle	
Ø3ø7	Vertical+horizontal	[K]	Horizontal+vertical	[L]
Ø3/7	180° Arc	[U]	−180° Arc	[CAPS] [U]
Ø32/	90° Arc	[Y]	−90° Arc	[CAPS] [Y]
Ø3Ø9	Repeat construction	[M]		

COPY, SAVE AND STORE

Code	Command	Keys
Ø222	Copy screen (paper advance)	[Z]
Ø25Ø	Copy screen	[CAPS] [Z]
Ø293	Save screen	[CAPS] [K]
Ø3Ør	Save program	[CAPS] [S]
Ø24r	Load next screen	[CAPS] [J]
Ø26g	Copy screen to J	[CAPS] [C]
Ø2/9	Exchange display J	[CAPS] [J]
Ø2/r	Exchange display K	[CAPS] [K]

ADVANCED GRAPHICS MANIPULATION

Code	Command	Keys
Ø2/6	Start tracing to array	[T]
Ø262	Stop tracing to array	[CAPS] [T]
Ø3/4	Start retracing	[R]
Ø3/5	Start selective retrace	[S]
Ø2g7	Array programmed stop	[A]
Ø4ør	Set scale (by drawing)	[CAPS] [D]
Ø4øb	Set scale (by entry)	[CAPS] [E]
Ø26ø	Reset scale to normal	[CAPS] [R]
Ø2Ør	Define user graphics	[CAPS] [U]
Ø29ø	Read x,y	[CAPS] [Z]

5. Useful Hints and Suggestions

1. **Handling** The RD Digital Tracer is a precision drawing instrument and should be handled with appropriate care. In particular the Tracer arm pivots should not be forced against their end stops. Calibration errors or permanent damage could be caused.

2. **Edge Connector** The most common cause of faulty or intermittent operation in any Spectrum accessory is poor contact with the edge of the computer's printed circuit. **WITH THE POWER OFF** connect and disconnect the socket several times for self-cleaning action on the contacts.

3. **Fine Detail** Highly detailed screen displays are best created when it is possible to use a reduction scale from a large original drawing. When tracing smooth curves, however, do not trace too slowly – this would accentuate inevitable hand jitter.

Remember' that the computer can do no better than select the pixel which is nearest the Tracer position at any instant.

4. **INK Colour changes** The INK colour of a shaded area can be changed retrospectively. Try selecting the new INK colour, then plotting key [Q] within the shaded area. Individual character squares will be changed one by one.

5. **False Perspective** An interesting effect is created by reducing the vertical scale, retaining the original horizontal scale. (This is not a true "vanishing point" technique.)

6. **Merging with User Program** The Tracer software uses line numbers commencing at 8ØØØ. If user software is limited to line 7999 the segments may be combined with the Spectrum MERGE command.

7. **Conserving Memory** The "Tracer 48" program utilises approximately 20K of array and display storage. If memory is required for other purposes two modifications are readily incorporated.
a) Reduce the dimensions of the trace array, by changing the value of the variable "tot" in line 8022.
(Conversely this may be increased from 2000 to 4000 for large arrays.)
b) Sacrifice one or both of the display stores. The CLEAR command in the loader program sets RAMTOP to reserve display store space.

CLEAR 50943 reserves J and K stores.

CLEAR 57855 reserves J store only.

CLEAR 64767 reserves machine code space only.

N.B. One of these CLEAR commands MUST be executed before loading the BASIC program. Normally this is done in the loader title program, but if merging with user software, the latter must make suitable provision.

8. **Modifications to Software Supplied** REM statements are included in the program listing to assist the user in incorporating further individual requirements.
The program is laid out as follows:-

8000 – 8099	Initialisation of variables.
8100 – 8199	Main loop, updating x,y, and detecting keys pressed.
8200 – 8455	Key Command sub-routines. Note that when a key with code 'n' is pressed, the program jumps to the sub-routine at line number (8200 + n).
8500 – 9899	Various sub-routines.
9900 – 9999	SAVE and LOAD routines.

6. Using the Sinclair Microdrive

The software can be made microdrive compatible by merging in the segment **M/drive,** supplied on the tape.

The procedure is as follows:-

1. Load the main program
2. BREAK the program
3. Type **MERGE " M/drive**[ENTER] and start tape
4. When merging is finished, run the program
5. Insert a microdrive cartridge in **Drive 1**
6. Now pressing [SYMBOL SHIFT][S] will save the program to microdrive 1, automatically

The BASIC program will be saved under the name "run" and the machine code under the name "M/C. To load and run the program automatically, from microdrive 1, simply press the key-word [RUN][ENTER]

This procedure assumes that you are using microdrive 1 and there are no other programs already on the microdrive named "run"

Warning: If a microdrive error is issued, correct the error (see Microdrive and Interface 1 manual), and type:

GOTO 8100

and try again.

7. Technical Specification

The RD Digital Tracer pack (Sinclair ZX version) includes:

Hardware Tracer arms connected by 0.9 metres of cable to the electronic interface.

Software Cassette DT-3 contains standard tracing program in BASIC and machine code for use on Sinclair ZX Spectrum (16K and 48K).

Instruction Manual Full instructions for simple installation and operation of the Tracer, including program listings in BASIC.

Tracing Sheet (A4 for RD-ZX/A4. A3 for RD-ZX/A3) A printed grid with line and column numbers and X and Y coordinates. Facilitates positioning and squaring of the original drawings prior to tracing.

Template Enables tracing sheet to be positioned correctly with respect to the base of the Tracer.

COMPATABILITY

Direct connection All ZX Spectrum computers (16K and 48K).
Connector Double sided gold-plated 23-way edge connector.
Access Port 31 on 8-bit address bus. No interference with Sinclair Accessories or memory mapped accessories from other manufacturers.
Bus Connections Address lines-A0 to A7.
Data lines – D0 to D7. Control lines RD, WR, IORQ.
Power supplies – 0v,+ 5V @ 25mA.

Mechanical details	RD-ZX/A4	RD-ZX/A3
Nominal tracing area	256 x 176mm	400 x 275mm
Maximum tracing area (approx)	300 x 300mm	500 x 330mm
Resolution at standard scale	1mm	1.5mm
Resolution when scaled (typical)	0.3mm	0.5mm
Accuracy (typical)	±2% of full scale	±0.5% of full scale
Maximum error (using Autocallibration)	N/A	±1% of full scale
Angular measurement range	100°	160°
Effective arm length	250±2mm	250±2mm